

Construction Report

-Experimental Feature-

**Lumimark Traffic
Striping System**

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ABSTRACT

The Lumimark Traffic Marking System was recently introduced to the Utah Department of Transportation (UDOT) as a more durable alternative to traditional pavement marking materials. Lumimark is a polymer-modified cementitious striping system specifically designed for use in portland cement concrete pavement (PCCP). Its claimed advantages include a stronger bond and thermal compatibility with the concrete pavement, durability and cost-effectiveness (compared to other high performance systems) and retroreflectivity equal to or higher than that of other marking systems.

Test panels were installed in Regions Two and Three to evaluate product under varying traffic and weather conditions, and to establish a point of comparison with other traffic striping systems currently being used by UDOT. Approximately 150 m of Lumimark material were applied on Westbound North Temple off ramp to Airport/I-80 Westbound (Region Two), and on Southbound University Avenue just before the 1200 South intersection (Region Three).

This construction report presents a description of the Lumimark Traffic Marking System, the experimental feature sites where testing is underway, conditions during product installation, material properties test results, and initial performance evaluation. Preliminary product evaluation is consistent with anticipated results and expectations. Additional performance data gathered during the upcoming twelve months will be used as deciding criteria for future Lumimark applications in UDOT projects. Furthermore, since product was installed using walk-behind equipment, future product applications will also depend on installation procedures and quality control at expected production rates.

Introduction

The Utah Department of Transportation (UDOT) was recently introduced to Lumimark, an innovative pavement marking system manufactured by Master Builders Technologies (MBT). Lumimark is a polymer-modified cementitious portland cement concrete pavement striping system, available for white and yellow applications. UDOT, in collaboration with MBT and Lumimark Systems Inc. (LSI) set up two test sections to evaluate product performance under varying traffic and weather conditions. This construction report presents a brief description of each test site, including the exact location of each experimental feature, conditions during product installation, and a description of the materials sampling method followed during product installation. The report presents material testing and performance results, including initial and 28 day retroreflectivity and colorometer readings.

Test Sections and Product Installation

Region Two (W North Temple off ramp, near Salt Lake City International Airport)

Location

A 156 m test section of the Lumimark Traffic Striping System was installed in the vicinity of the Salt Lake International Airport. The test section was chosen based on several parameters including roadway condition and geometry, pavement age, traffic, and accessibility. The Experimental Feature is located on the Westbound North Temple off ramp to Airport/I-80 Westbound, between STA 1234+10 (by the *Airport Info: Tune Radio to 1200 AM* green sign) and STA 1238+00 (by the Surplus Canal bridge). This two lane portland cement concrete pavement road was built around 1987 and remains in excellent condition, showing no signs of faulting or rutting across traveled lanes and shoulders. Both lanes were restriped during test section installation, including the solid yellow shoulder line, the white skip line and the solid white shoulder line on the right hand side of the road.

Installation

The Lumimark Traffic Striping System was installed in Region Two between August 28 and 29, 2000. Weather conditions were fair to partly cloudy with 70 °F ambient temperature during product installation. Crews begun cutting a 6.5 mm deep groove on top of the solid yellow outside shoulder line. The grooving tool left a clean, even cut on the concrete (See Figure 1). Surface preparation before product installation included washing with a high pressure water spray and blowing the water and any laitance with compressed air. The Lumimark surface material was installed using walk-behind portable equipment. The bagged material (with premixed glass beads) was mixed in the hopper and applied directly on the concrete groove. Additionally, Type 1 and 3 glass beads were sprinkled on the surface material during application through a gravity-fed funnel and finished by an air curtain. Following product installation, crews sprayed a liquid cure over the striping surface. Surface material cure time was approximately 1.5 to 2.0 hours under prevailing weather conditions. The ramp was reopened to traffic after a successful surface penetration test was performed by MBT. The following day, crews grooved the white skip and solid lines, cleaned the surface and completed product installation (See



FIGURE 1. PCCP GROOVE



FIGURE 2. WHITE LUMIMARK STRIPE

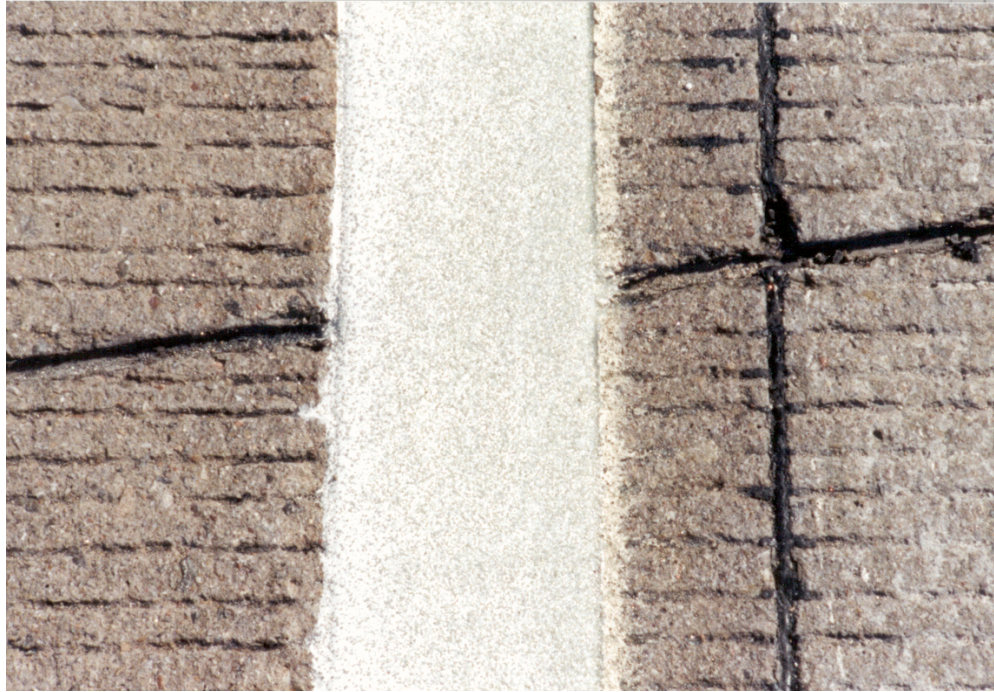


FIGURE 3. WHITE LUMIMARK STRIPE



FIGURE 4. WHITE LUMIMARK SKIP



FIGURE 5. YELLOW LUMIMARK STRIPE

Figures 2 through 5).

Region Three (1200 South and University Avenue, East Bay, Provo)

Location

A 152 m test section of the Lumimark Traffic Striping System was installed in University Avenue, near 1200 South in Provo (UDOT Region Three). The test section was chosen based on several parameters including roadway condition, pavement age, traffic, and accessibility. This Experimental Feature is located on Southbound University Avenue just before the 1200 South intersection in East Bay. It is located between STA 123+40 (by parking area North of the Wendy's parking lot located on the West side of University Ave) and STA 118+33 (near the entrance to the car wash South of Shoney's parking lot). This two lane (plus median turnaround lane) portland cement concrete pavement road was built in 1994 and remains in excellent condition, showing no signs of faulting or rutting across both traveled lanes and shoulders. During test section installation both lanes were restriped, including the solid yellow turnaround lane line, the inside and the outside white skip lines.

Installation

The Lumimark Traffic Striping System was installed in Region Three between August 29 and 31, 2000. Weather conditions were partly cloudy during the first night, and rainy during the second night (product installation took place during the night to avoid traffic congestion). During the night of the 29th, Crews begun cutting a 6.5 mm deep groove on top of the solid yellow turnaround lane line. The grooving tool left a clean, even cut on the concrete. Surface preparation before product installation included washing with a high pressure water spray and blowing the water and any laitance with compressed air. The Lumimark surface material was installed using walk-behind portable equipment. The bagged material (with premixed glass beads) was mixed in the hopper and applied directly on the concrete groove. Additionally, Type 1 & 3 glass beads were sprinkled on the surface material during application through a gravity-fed funnel and finished by an air curtain. Following product installation, crews sprayed a liquid cure over the striping surface. The following night, crews completed the grooving operation by removing the skip white striping on both lanes of the road after which the white surface material was placed (See Figures 6 through 8).



FIGURE 6. WHITE LUMIMARK STRIPE



FIGURE 7. WHITE LUMIMARK STRIPE



FIGURE 8. YELLOW LUMIMARK STRIPE

Laboratory Testing

Region Two

During product installation, MBT and UDOT collaborated preparing and collecting samples for laboratory testing in accordance with the testing plan submitted by MBT (A copy of the Testing Plan is found in the Appendix). Following are the results for the samples prepared during test section installation in Region Two.

Freeze/Thaw testing

Solid beams were prepared on site per MBT's specifications. After initial set time, they were transported to UDOT's materials lab where they were moist cured for 1½ days and shipped to MBT's testing facility in Cleveland, OH for testing. Unfortunately, all beams were damaged during shipping and no freeze/thaw testing was performed on field samples. The results of a freeze/thaw test performed in July 2000 are included in the Appendix for reference purposes.

Slant-Shear Bond testing

Concrete cylinders were prepared and brought on site per MBT's specifications to be filled with Lumimark material in preparation for slant-shear testing. After initial set, all cylinders were transported back to UDOT's materials lab for moist cure (1½ days) and shipped to MBT's testing facility in Cleveland, OH for testing. Test results reported by MBT are presented in tabulated format:

TABLE 1. SLANT-SHEAR BOND TEST - REGION TWO

Specimen No.	Bond Strength (psi)	Date Cast	Color	Failure
1	3400	8/28/00	White	Product
2	3300	8/28/00	White	Product/Substrate
3	3430	8/29/00	White	Product
4	3280	8/29/00	White	Product/Substrate
5	3250	8/29/00	Yellow	Product
6	2930	8/29/00	Yellow	Product

*Samples with a minimum bond strength of 1000 psi should be considered for use.

Region Three

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TABLE 2. SLANT-SHEAR BOND TEST - REGION THREE

Specimen No.	Bond Strength (psi)	Date Cast	Color	Failure
7	*3420	8/30/00	Yellow	Product/Substrate
8	*3270	8/30/00	Yellow	Product
9	*3550	8/31/00	White	Product/Substrate
10	3520	8/31/00	White	Product

*Samples with a minimum bond strength of 1000 psi should be considered for use.

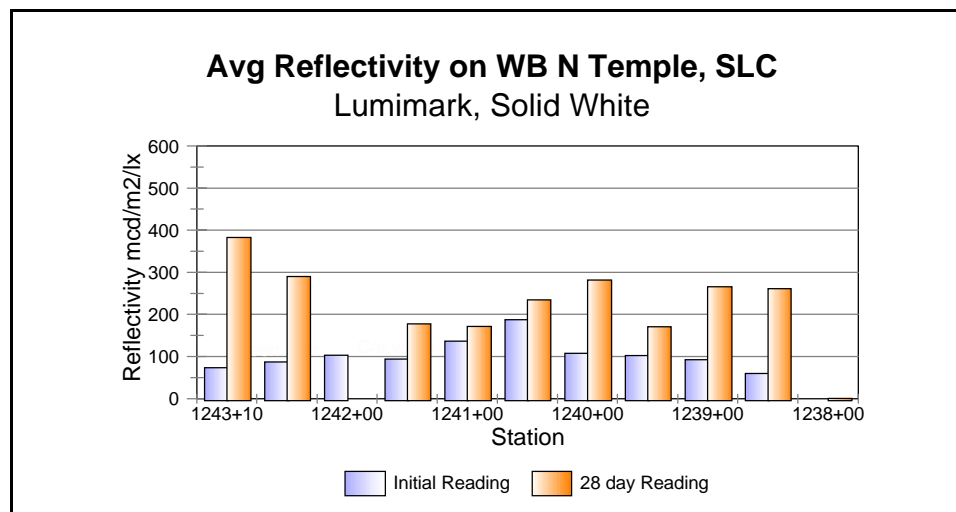
Field Data

Region Two

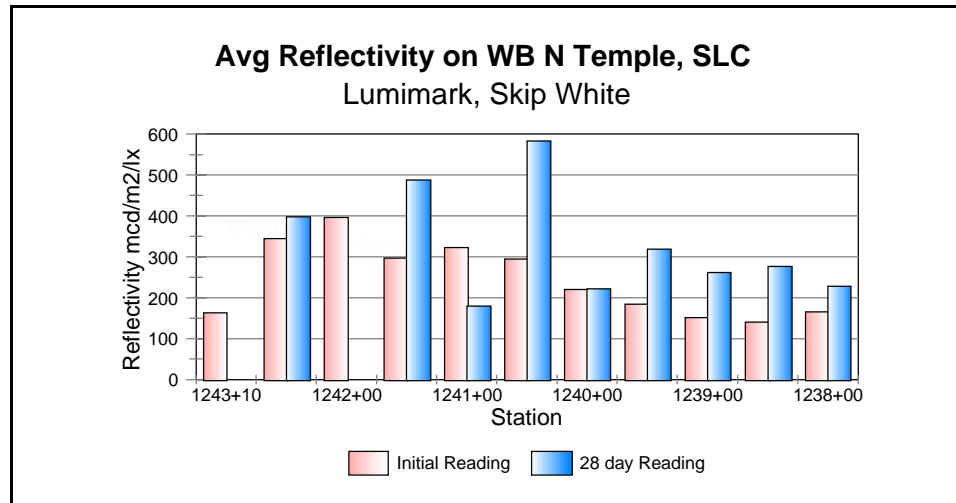
Retroreflectivity

As indicated in the Work Plan, field data readings were taken immediately following, and 28 days after product installation. UDOT Field data readings include retroreflectivity ($\text{mcd}/\text{m}^2/\text{lux}$, using an LTL 2000 Retrometer, by Delta) and yellowness index (using a MiniScan Spectrocolorometer, by Hunter). Although the retroreflectivity readings after installation were not as high as what has been observed in new installations of competing traffic markings, following 28 days of being exposed to traffic, a considerable increase in retroreflectivity was observed. While the average retroreflectivity reading on the white skip line was around $244 \text{ mcd}/\text{m}^2/\text{lux}$ after installation, the same parameter rose to $328 \text{ mcd}/\text{m}^2/\text{lux}$ just 28 days after installation (an increase of about 35%).

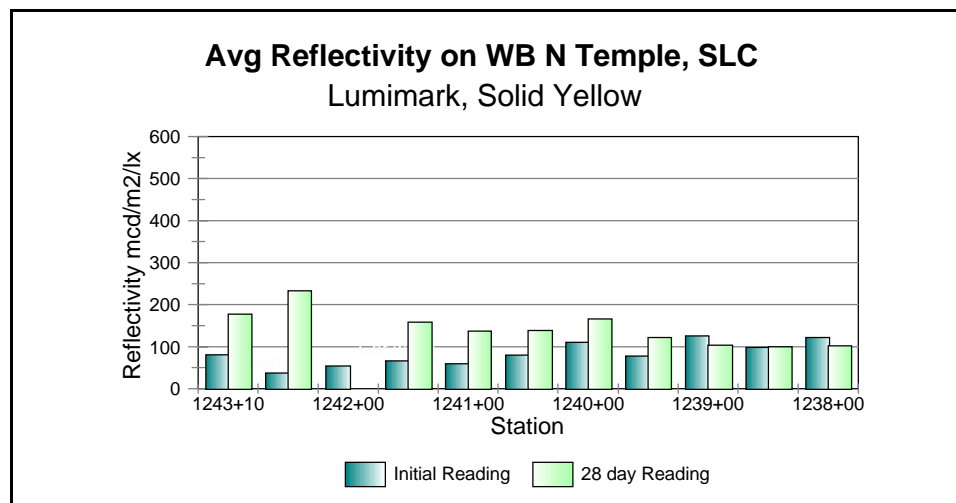
The solid yellow line showed a 74% increase in retroreflectivity (from an average of $83 \text{ mcd}/\text{m}^2/\text{lux}$ to $144 \text{ mcd}/\text{m}^2/\text{lux}$). The most significant increase, however, was observed on the white solid line, from an average retroreflectivity value of $100 \text{ mcd}/\text{m}^2/\text{lux}$ to $240 \text{ mcd}/\text{m}^2/\text{lux}$, for a increase of 140% reflectance. This contrast seems to imply that wear on the marking surface from weaving cars may actually have a refreshing effect on the glass beads held within the material matrix. The following charts illustrate the findings presented herein (raw data can be found in the Appendix in tabulated form):



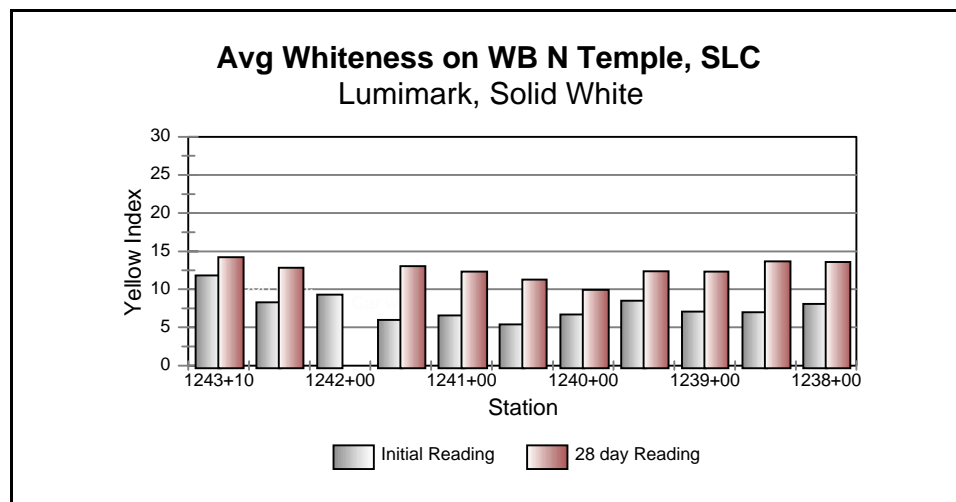
GRAPH 1. REGION TWO



GRAPH 2. REGION TWO



GRAPH 3.REGION TWO



GRAPH 4. REGION TWO

MBT obtained additional retroreflectivity readings using an MX-30 Meter. However, the data submitted was not referenced to road stationing thus rendering a meaningful comparison useless. It should be noted nonetheless, that on average, MBT's readings were about 50% to 100% higher than those obtained by UDOT Research.

Tensile Bond Test

Pavement markings were tested for bond strength in accordance with ASTM D4541 . Failure modes include C: cohesive (within the product); S: substrate (in the concrete); B: bond line (at bond interface).

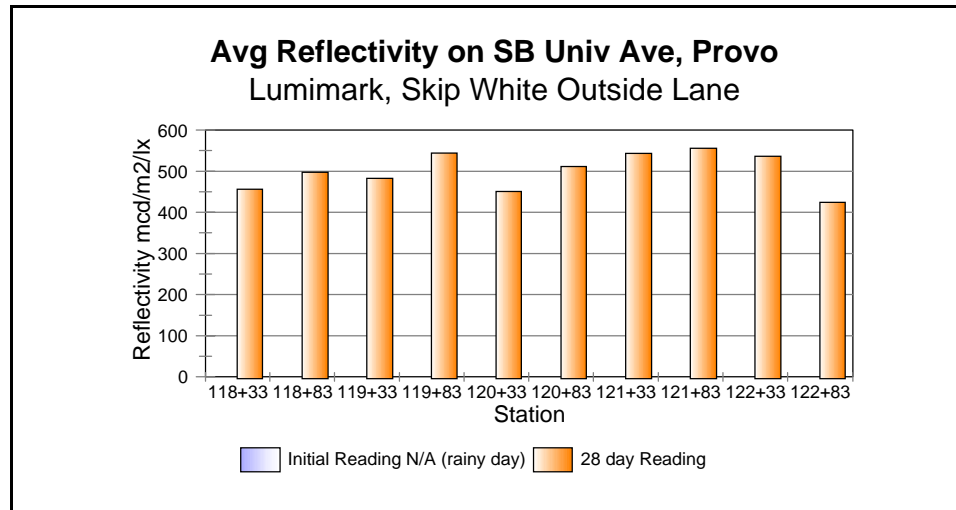
TABLE 3. TENSILE BOND - REGION TWO

Pavement Marking Type	Tensile Bond Strength (psi)	Failure Mode
White Solid	250	B
	200	Epoxy
	200	B
	250	B
Yellow Solid	150	B
	200	B
	150	B
	100	B
	150	B
White Skip	250	B
	200	B
	200	B

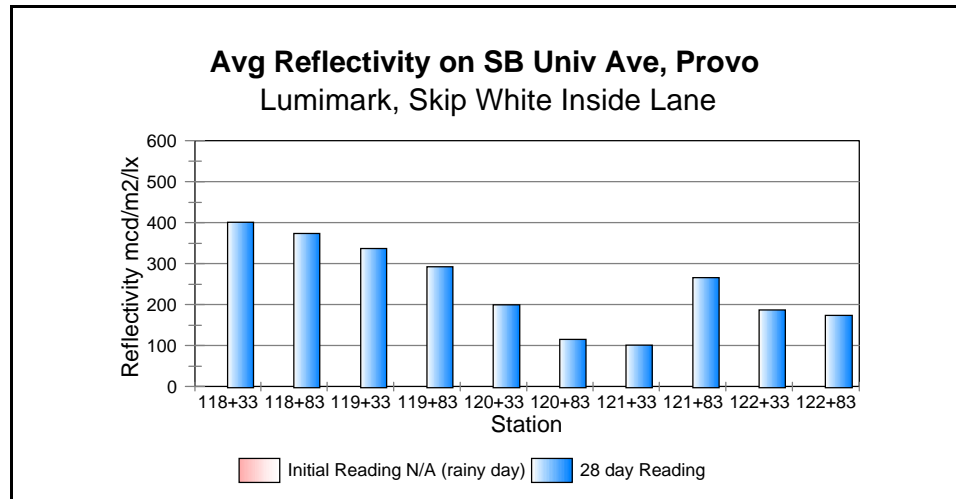
Region Three

Retroreflectivity

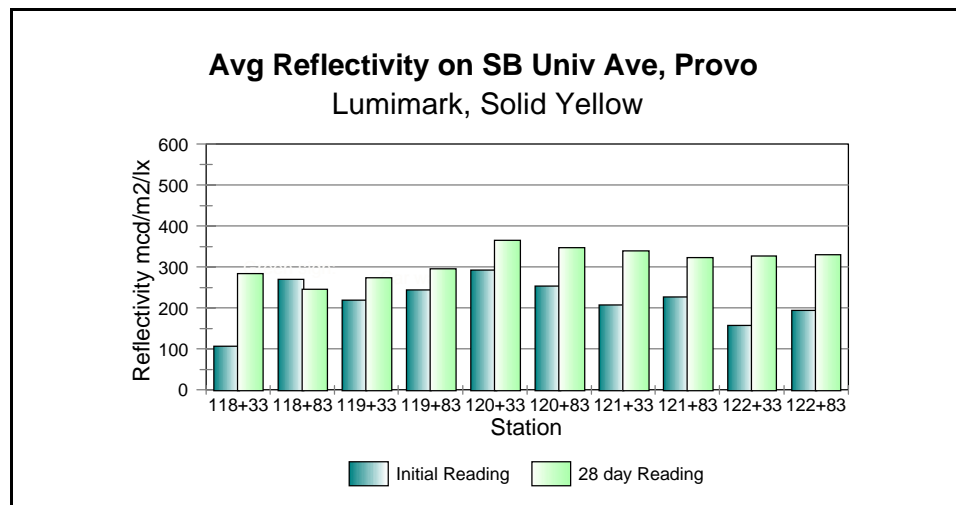
In accordance to the Work Plan, there were several attempts to obtain field data readings immediately following, and 28 days after product installation. As it was indicated earlier, product installation in Region Three took place under rainy conditions (both skip white and solid white were installed during the second placement night where it rained throughout the night into the early morning; see Figures 6 through 8). As a result of the prevailing weather, minor adjustments were made to the mix to prompt faster cure time, which made the material slightly less workable. This is somewhat evident by the rougher appearance of the finished product. Lingering rain did not allow for any retroreflectivity readings immediately after product cure (as a wet surface greatly distorts the readings obtained by the instrument). Therefore, the only retroreflectivity data available for comparison between immediate installation and 28 days after installation is the solid yellow line. As before, after 28 days of traffic, retroreflectivity values for solid yellow markings rose by almost 45%.



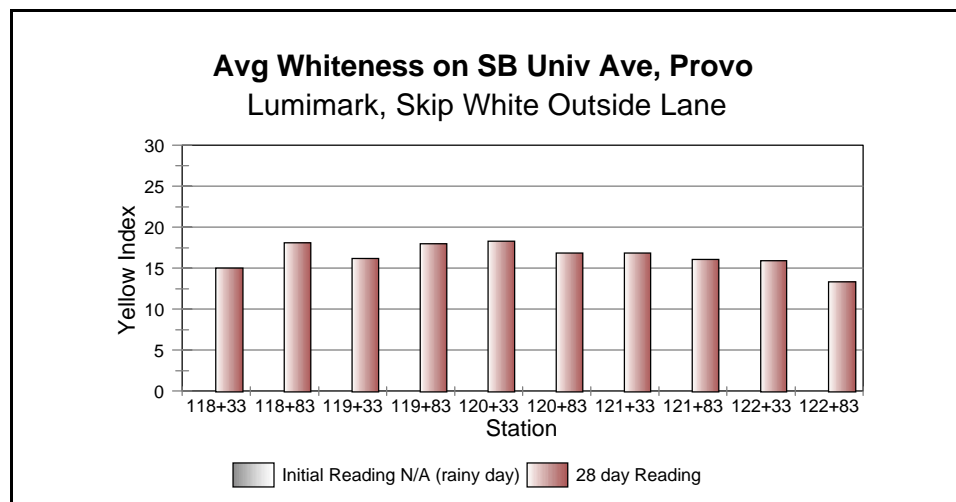
GRAPH 5. REGION THREE



GRAPH 6. REGION THREE



GRAPH 7. REGION THREE



GRAPH 8. REGION THREE

MBT obtained additional retroreflectivity readings with an MX-30 Meter. However, the data submitted was not referenced to road stationing thus rendering a meaningful comparison useless. It should be noted nonetheless, that on average, MBT's readings were between 100% and 150% higher than those obtained by UDOT Research.

Tensile Bond Test

Pavement markings were tested for bond strength in accordance with ASTM D4541 . Failure modes include C: cohesive (within the product); S: substrate (in the concrete); B: bond line (at bond interface).

TABLE 4. TENSILE BOND - REGION THREE

Pavement Marking Type	Tensile Bond Strength (psi)	Failure Mode
Yellow Solid	200	B
	250	B
	250	B
	200	B
White Skip	200	B
	225	B
	225	B
	200	B
	250	B

Conclusions

Installation of the Lumimark Traffic Striping System using walk-behind equipment in Regions Two and Three was efficient and took place according to schedule. Lingering rain during the second installation night in Region Three caused some concern about product applicability, proper cure time before exposure to traffic, and final quality (reportedly, this was the first Lumimark application in damp conditions). However, both installations have shown good adhesion, with no signs of stress or delamination. Moreover, both test sections reported good visibility of traffic markings and increased retroreflectivity after installation as indicated in product literature.

Since Lumimark installation took place with portable, non-production type equipment, this experimental feature will only evaluate material properties and marking performance under varying traffic and weather conditions. Practical rates of product installation, cure time, and overall quality using production equipment need to be addressed before Lumimark may be accepted for use in larger projects.

Recommendations

Based on present performance, the Development Section recommends product evaluation for another twelve months, consistent with the Work Plan for this Experimental Feature. Additional performance data gathered during the upcoming twelve months will be utilized as deciding criteria for future Lumimark applications in UDOT projects.

APPENDIX

TABLE 5. RETROREFLECTIVITY/YELLOW INDEX - REGION 2 TEST SITE (UDOT READINGS)

Immediately after product cure					28 days after product cure			
Station	Solid White	Skip White	Solid Yellow	Yellow Index	Solid White	Skip White	Solid Yellow	Yellow Index
1243+10	121	239	86	11.8	371	N/A	164	14.9
	48	134	67		415	N/A	117	13.7
	51	116	88		361	N/A	251	14.1
Average Reading	73	163	80	12	382	N/A	177	14
1242+50	57	347	45	8.3	330	443	257	12.4
	138	306	36		211	299	212	12.5
	67	381	31		328	451	230	13.6
Average Reading	87	345	37	8	290	398	233	13
1242+00	92	337	53	9.3	N/A	N/A	N/A	N/A
	95	458	70		N/A	N/A	N/A	
	123	394	40		N/A	N/A	N/A	
Average Reading	103	396	54	9	N/A	N/A	N/A	N/A
1241+50	89	302	52	6	191	470	134	13.6
	111	321	106		181	507	159	12.4
	82	269	40		161	487	181	13.1
Average Reading	94	297	66	6	178	488	158	13
1241+00	140	233	61	6.6	174	180	131	11.5
	137	266	66		170	N/A	111	13.0
	132	470	50		170	N/A	167	12.5
Average Reading	136	323	59	7	171	180	136	12

1240+50 Average Reading	276	321	52	5.4 5	255	581	143	11.5
	173	330	79		202	585	116	10.9
	114	233	107		247	N/A	155	11.4
	188	295	79		235	583	138	11
1240+00 Average Reading	80	152	84	6.7 7	239	200	108	11.5
	134	204	96		313	243	192	9.5
	108	303	151		293	N/A	198	8.8
	107	220	110		282	222	166	10
1239+50 Average Reading	81	238	58	8.5 9	215	319	105	13.1
	124	196	104		203	N/A	119	12.0
	102	120	70		94	N/A	140	12.0
	102	185	77		171	319	121	12
1239+00 Average Reading	81	173	126	7.1 7	286	236	94	11.5
	78	163	149		276	252	92	12.3
	119	117	102		236	297	124	13.2
	93	151	126		266	262	103	12
1238+50 Average Reading	64	161	59	7 7	260	277	92	13.7
	59	161	120		270	N/A	110	13.5
	57	100	115		254	N/A	98	13.8
	60	141	98		261	277	100	14
1238+00 Average Reading	78	158	189	9.2 8	195	161	78	14.8
	64	155	75		223	263	112	12.3
	76	183	101		186	261	115	13.2
	73	165	122		201	228	102	14
Average Reading	102	244	83	8	244	328	144	13
Percent Change					140	35	74	63

TABLE 6. RETROREFLECTIVITY/YELLOW INDEX - REGION 3 TEST SITE (UDOT READINGS)

Immediately after product cure					28 days after product cure			
Station	Skip White Out	Skip White In	Solid Yellow	Yellow Index	Solid White Out	Skip White In	Solid Yellow	Yellow Index
118+33	N/A	N/A	91	N/A	391	393	276	13.9
	N/A	N/A	118		488	378	306	18.4
	N/A	N/A	109		489	431	269	12.7
	N/A	N/A	106		456	401	284	15
Average Reading								
118+83	N/A	N/A	299	N/A	540	340	310	16.8
	N/A	N/A	243		560	335	220	18.5
	N/A	N/A	266		392	445	207	19.0
	N/A	N/A	269		497	373	246	18
Average Reading								
119+33	N/A	N/A	172	N/A	434	315	255	15.6
	N/A	N/A	192		510	386	286	17.7
	N/A	N/A	293		505	310	280	15.3
	N/A	N/A	219		483	337	274	16
Average Reading								
119+83	N/A	N/A	214	N/A	557	197	304	18.2
	N/A	N/A	207		519	312	322	18.6
	N/A	N/A	312		556	368	260	17.2
	N/A	N/A	244		544	292	295	18
Average Reading								
120+33	N/A	N/A	287	N/A	577	211	362	20.7
	N/A	N/A	308		389	347	346	15.8
	N/A	N/A	281		386	40	387	18.3
	N/A	N/A	292		451	199	365	18
Average Reading								

120+83 Average Reading	N/A	N/A	261	N/A	471	130	366	18.5
	N/A	N/A	226		523	113	320	16.6
	N/A	N/A	274		540	102	355	15.4
	N/A	N/A	254		511	115	347	17
121+33 Average Reading	N/A	N/A	232	N/A	525	77	329	18.3
	N/A	N/A	203		554	59	343	17.3
	N/A	N/A	187		550	168	347	15.0
	N/A	N/A	207		543	101	340	17
121+83 Average Reading	N/A	N/A	218	N/A	552	290	320	16.6
	N/A	N/A	220		615	241	266	18.2
	N/A	N/A	243		501	266	381	13.4
	N/A	N/A	227		556	266	322	16
122+33 Average Reading	N/A	N/A	159	N/A	479	163	329	13.7
	N/A	N/A	146		610	200	361	17.0
	N/A	N/A	166		521	198	292	17.0
	N/A	N/A	157		537	187	327	16
122+83 Average Reading	N/A	N/A	210	N/A	413	211	347	13.5
	N/A	N/A	154		409	189	322	12.9
	N/A	N/A	219		451	121	321	13.6
	N/A	N/A	194		424	174	330	13
123+40 Average Reading	N/A	N/A	189	N/A	354	169	N/A	13.5
	N/A	N/A	75		345	133	N/A	13.7
	N/A	N/A	101		511	113	N/A	13.4
	N/A	N/A	122		403	138	N/A	14
Average Reading	N/A	N/A	197	N/A	455	222	285	15
Percent Change					N/A	N/A	44	N/A